TOSHIBA

Leading Innovation

The Contribution of Flash to the Information Explosion

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TOSHIBA Corporation

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TOSHIBA eco style

Toshiba Group contributes to
the sustainable future of planet Earth.

It is not the strongest

of the species that survives,

nor the most intelligent that survives.

It is the one

that is the most adaptable to change.

Charles Darwin

Semiconductor Industry Business Environment

Information Explosion and the Future of Flash

Technology Challenges

Toward the Future

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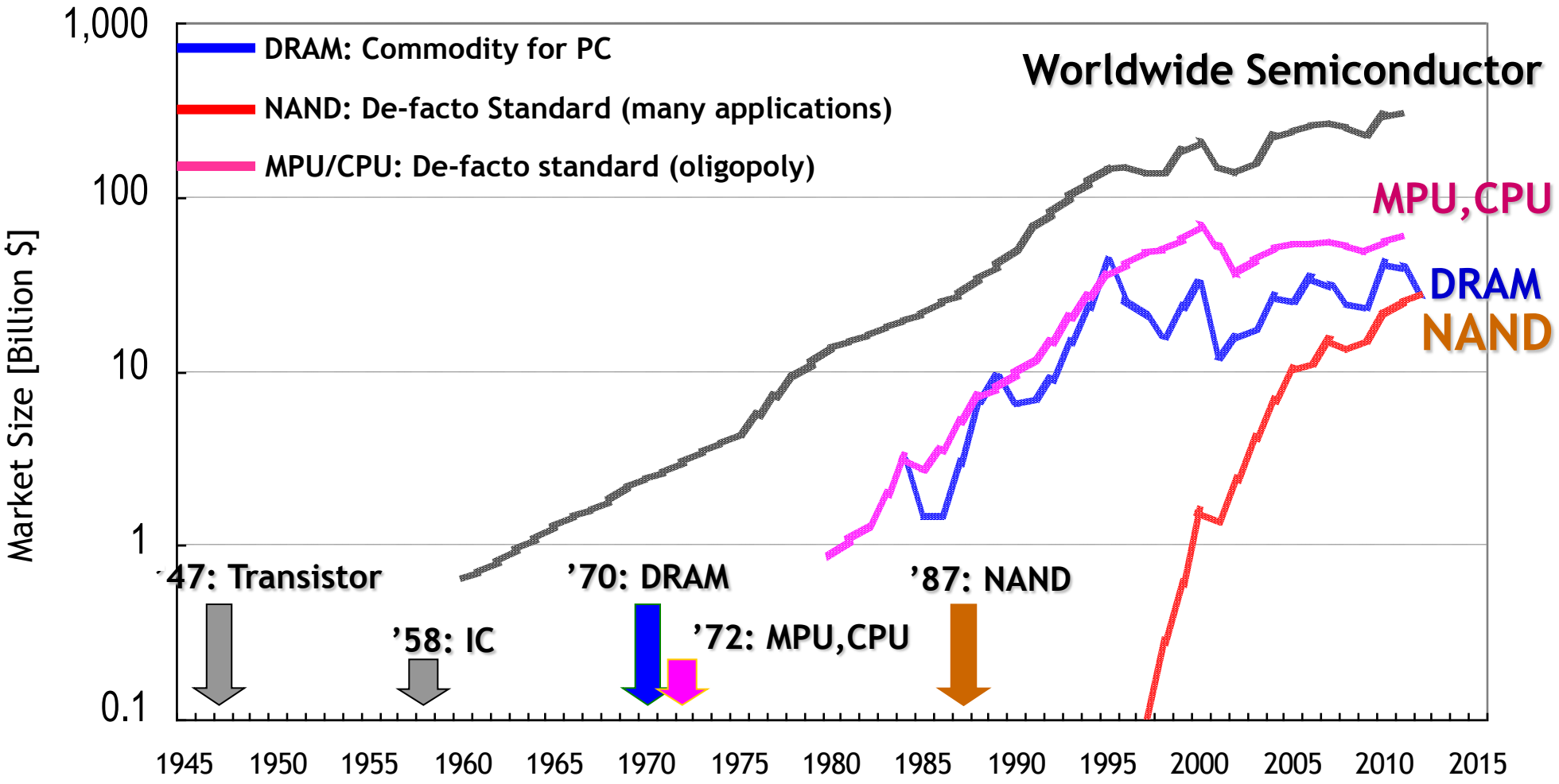
Semiconductor Market History

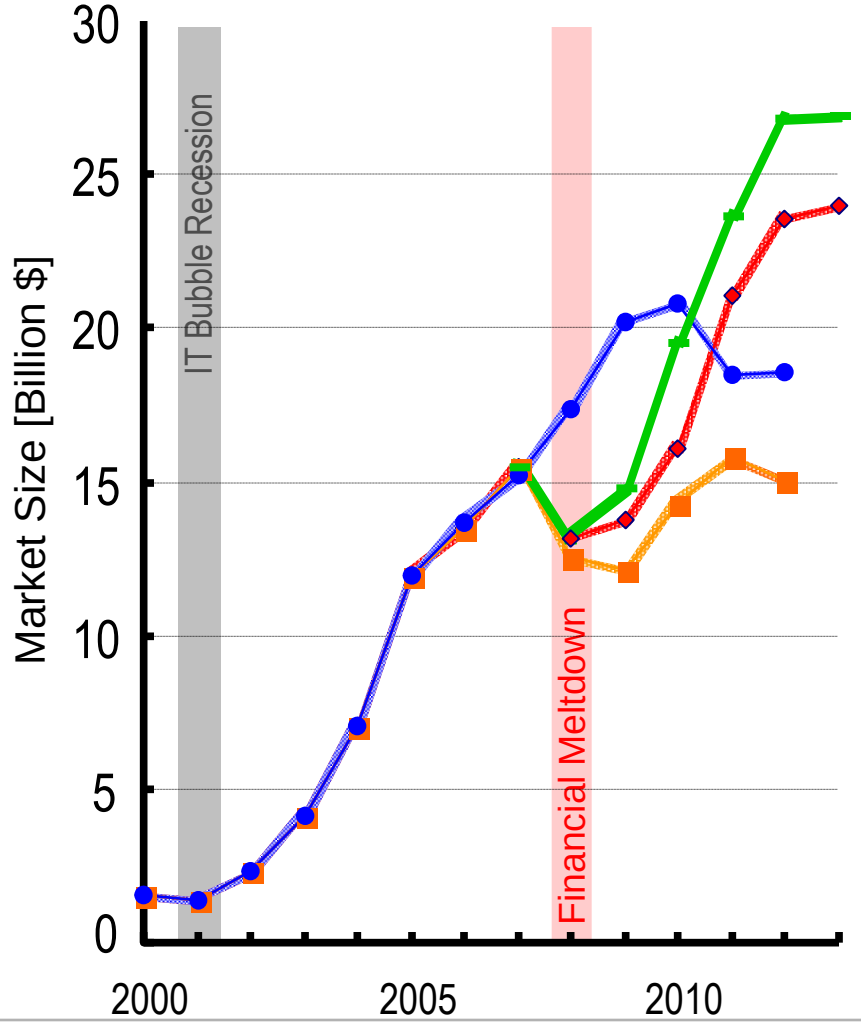


Source : WSTS

Worldwide NAND Flash Market

2001 : IT bubble recession

2008/Sep : Financial Meltdown



2008 – 2013
Market Growth

2010.05 : estimate +15% CAGR

2009.09 : estimate +13% CAGR

2008.04 : before Financial Meltdown

2009.01 : right after Financial Meltdown

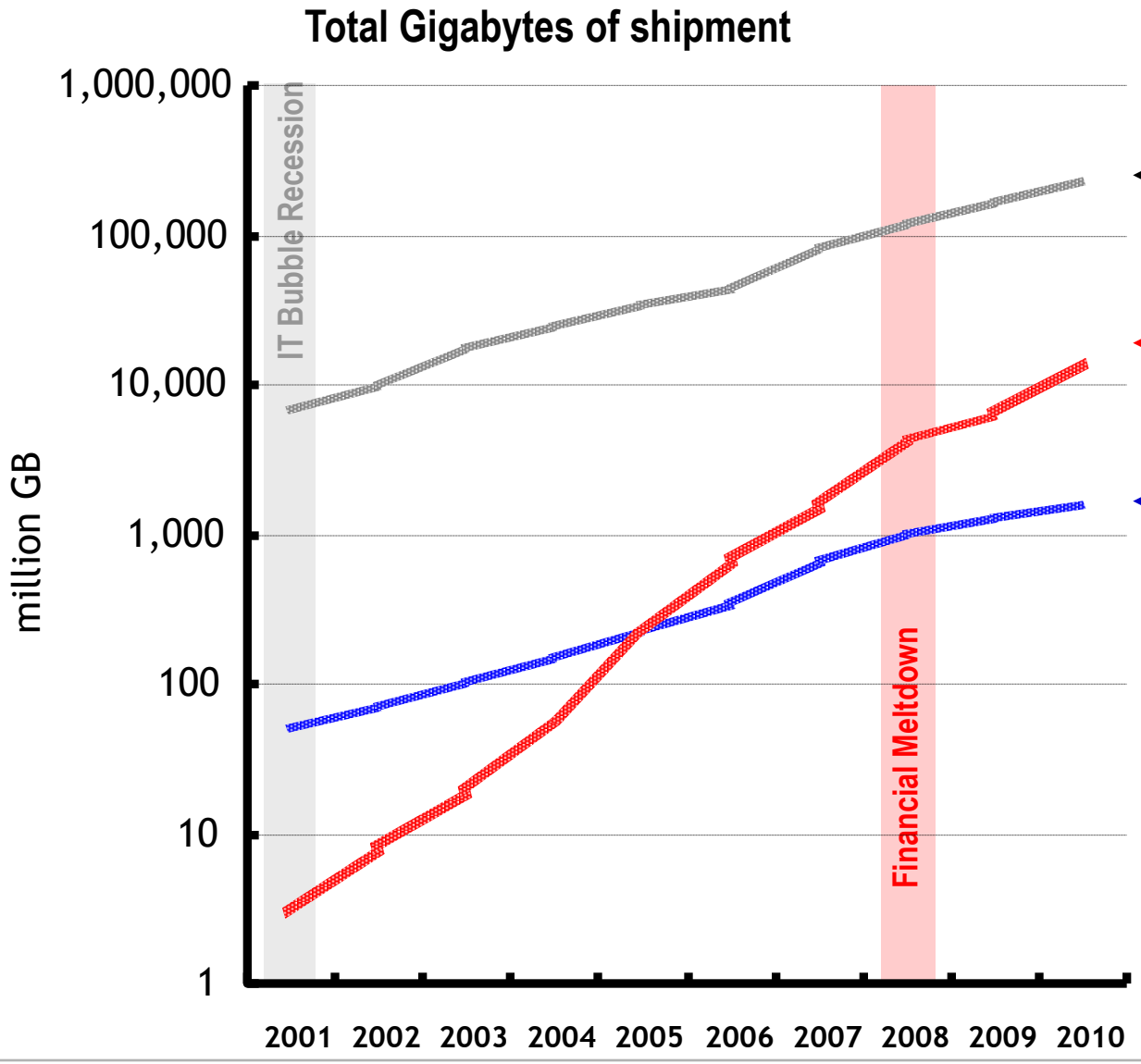
NAND Market

+15% CAGR 2009-2013 can be expected.
Unlike other semiconductor devices, quick recovery is being achieved.

Toshiba is confident that the Flash market will recover the surpass pre-crisis estimates.

Source : WSTS + Gartner + TSB

NAND Flash Bit Growth



CAGR
2001- 2010

HDD +45%

NAND +156%

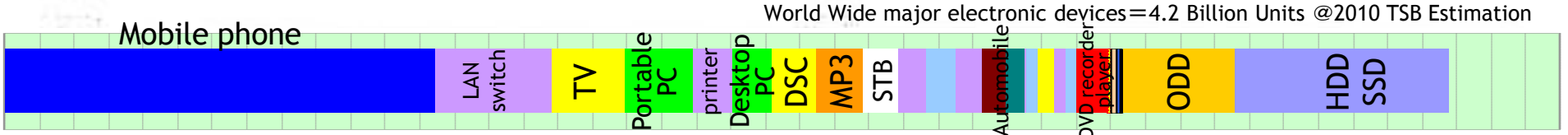
DRAM +47%

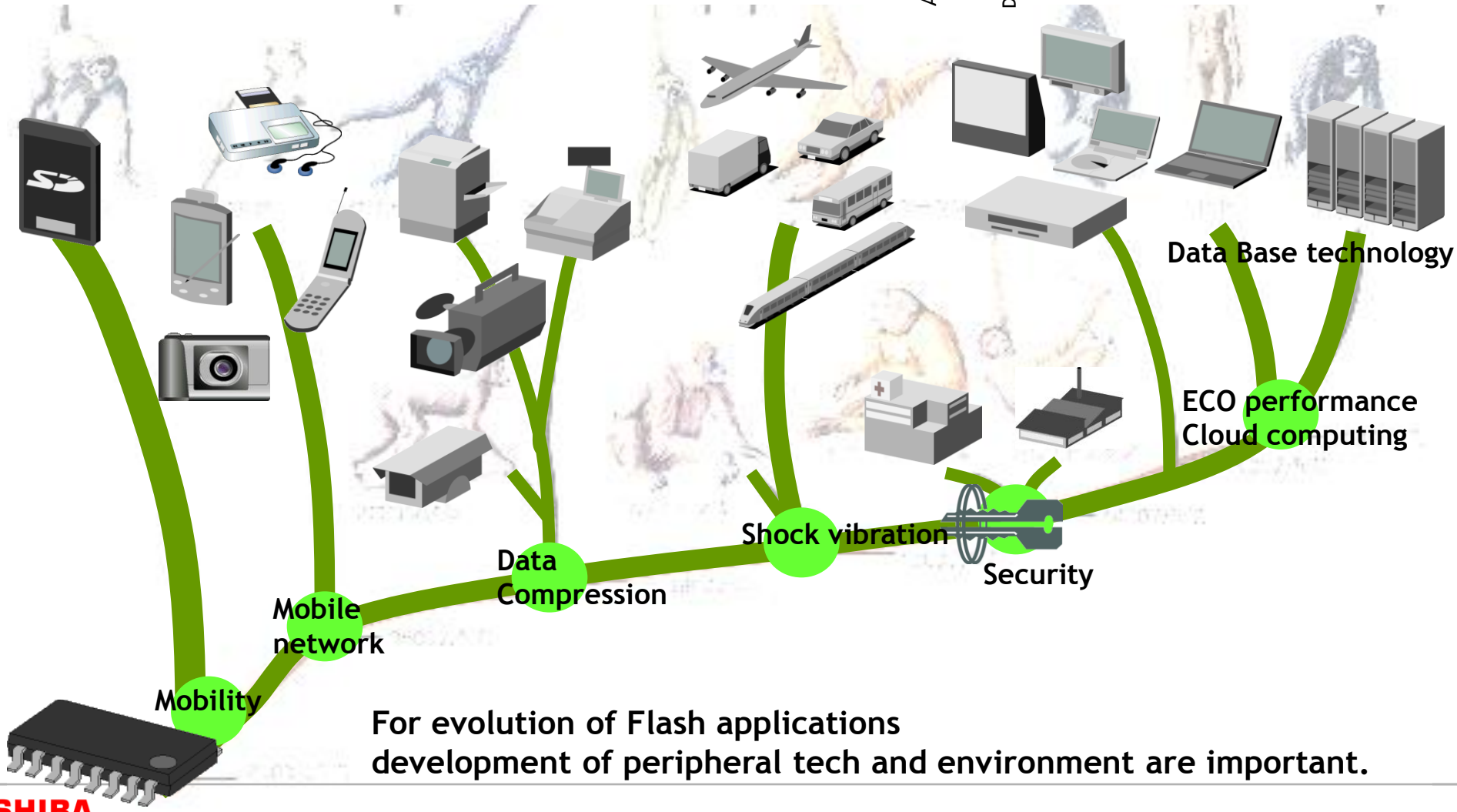
NAND growth rate is the highest of all semiconductors.

And beyond 2010 is expected to continue to grow.

Source:TSR(HDD) & iSuppli & Gartner (DRAM/NAND)

Diversity of Flash Applications



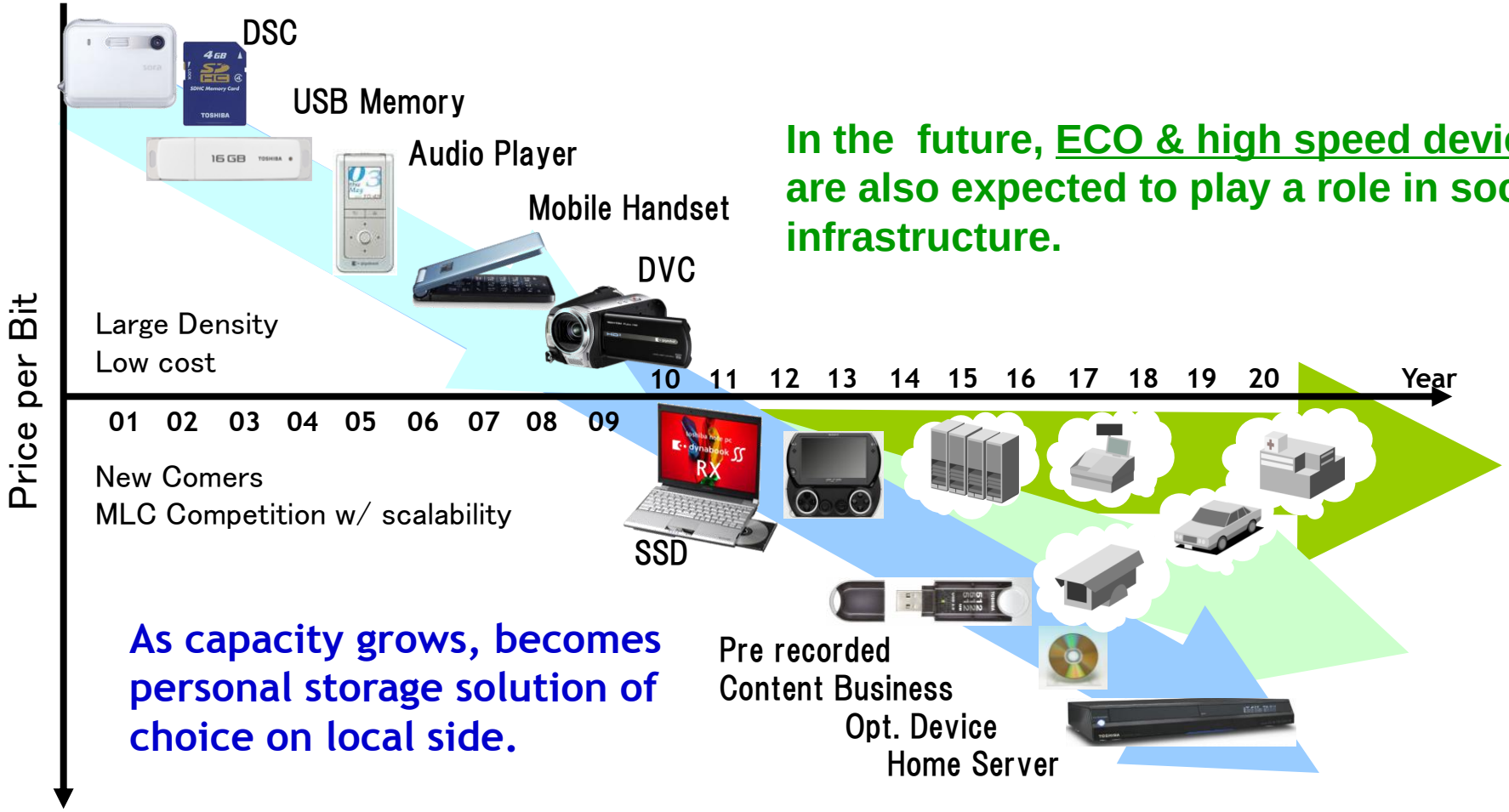


For evolution of Flash applications development of peripheral tech and environment are important.

Forecast : Changing Role of Flash

Expansion of NAND applications

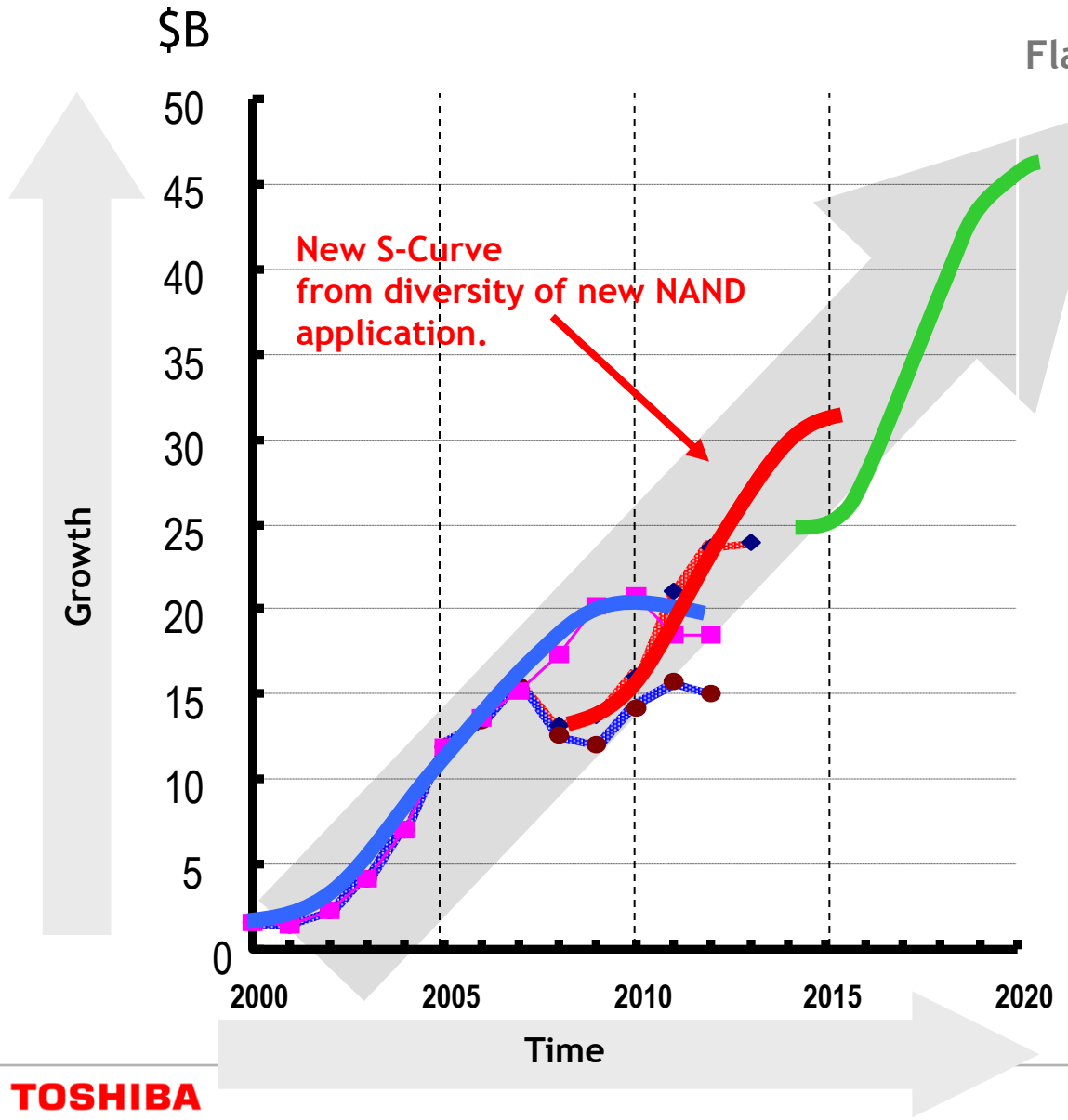
- ⇒ **We provide various types of NAND products for new applications**
- ⇒ **Flash will be more important in 2020**



In the future, ECO & high speed devices are also expected to play a role in social infrastructure.

As capacity grows, becomes personal storage solution of choice on local side.

NAND Flash Market Expansion



Flash market will continue to grow

New market
from information explosion

Launch post NAND, post-post NAND

Emerging Markets
from expanding NAND application

De-facto standardization in
existing digital consumer market

Source : Gartner and TSB

Semiconductor Industry Business Environment

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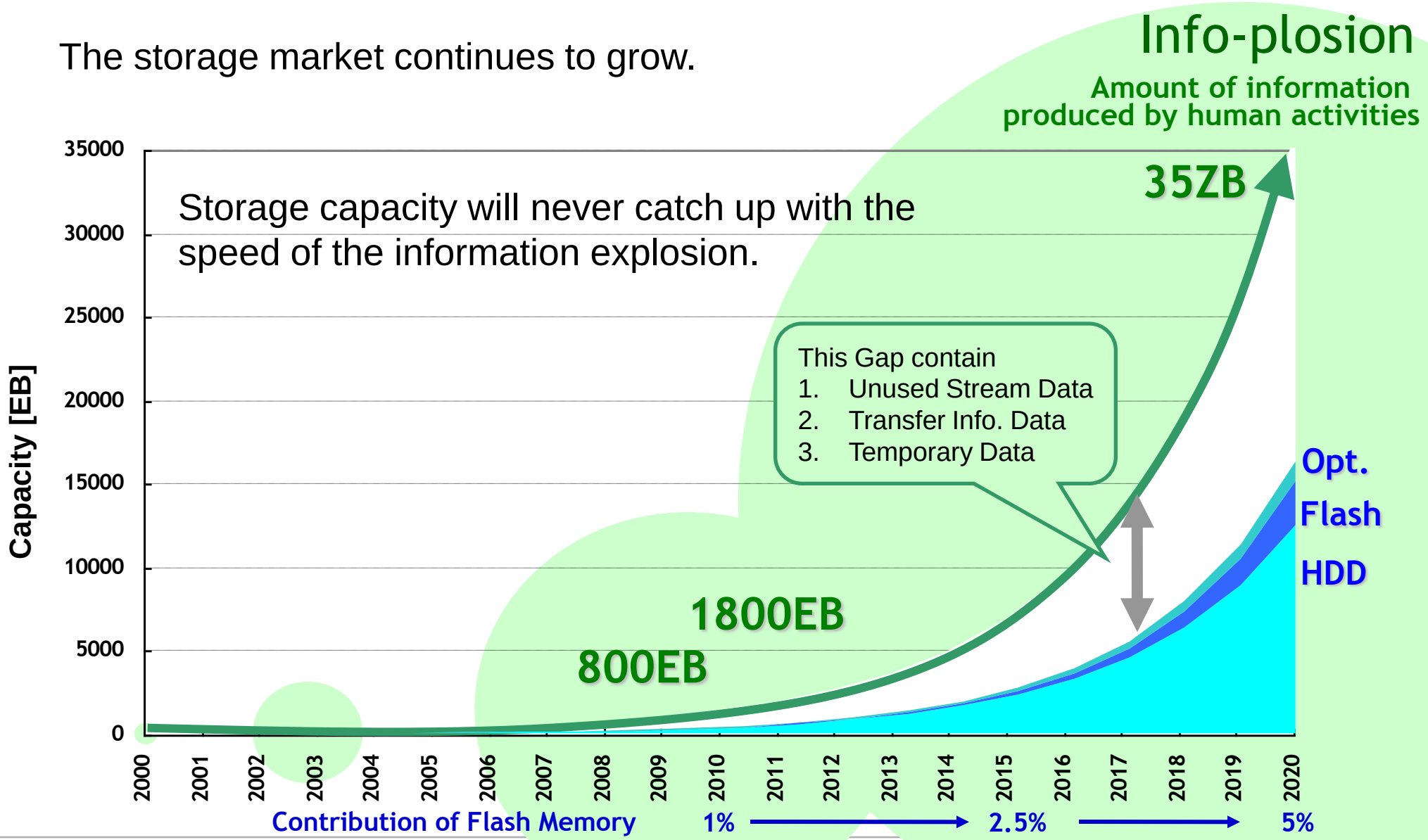
Storage Market Forecast

The storage market continues to grow.

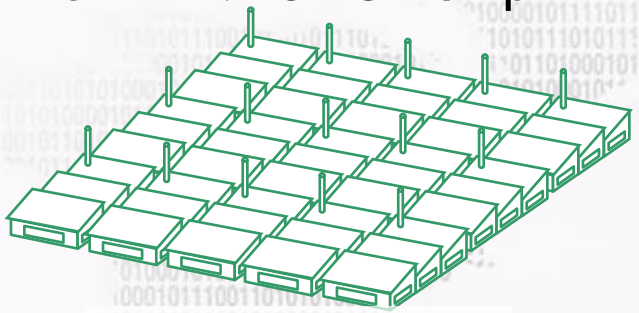


出展：TSR社(HDD)、日本記憶メディア工業会(CD/DVD/BD) ベースにTSB 試算。情報生成量/利用可能ストレージ(IDC白書)

Info Sphere (Images of 35ZB)

ZB = 1,000EB = 1,000,000PB = 1,000,000,000TB

3Xnm MLC 4GB chip



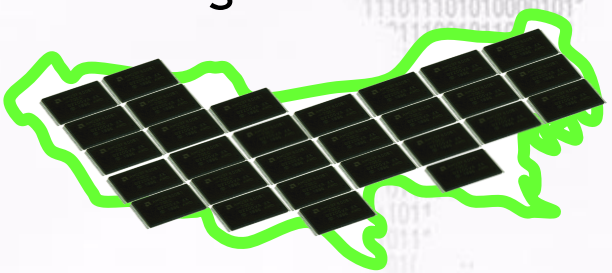
10,000 Fabs

stacked DVDs

27times the distance to the moon

35ZB

Tiling 4GB TSOP

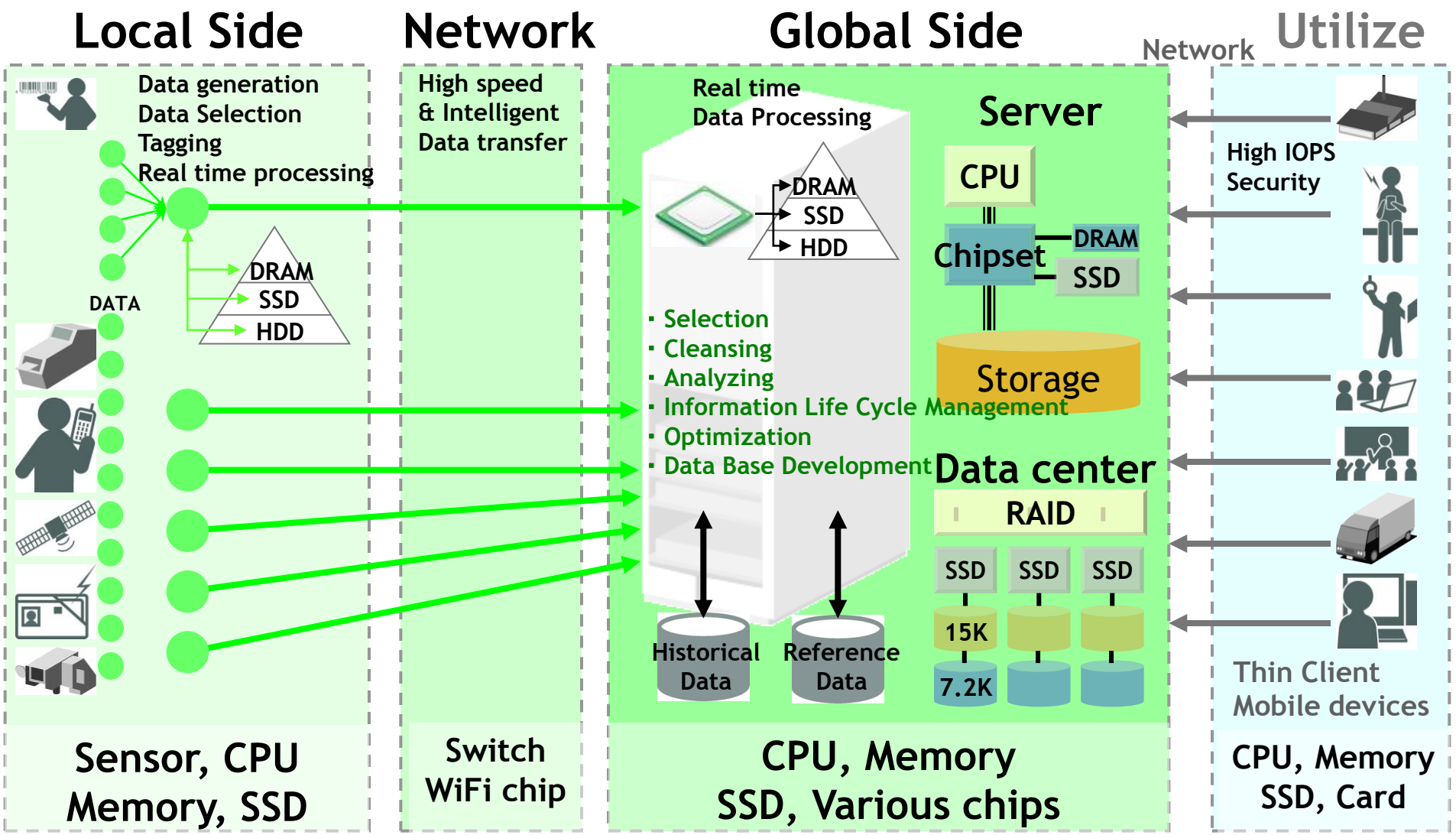


TOKYO

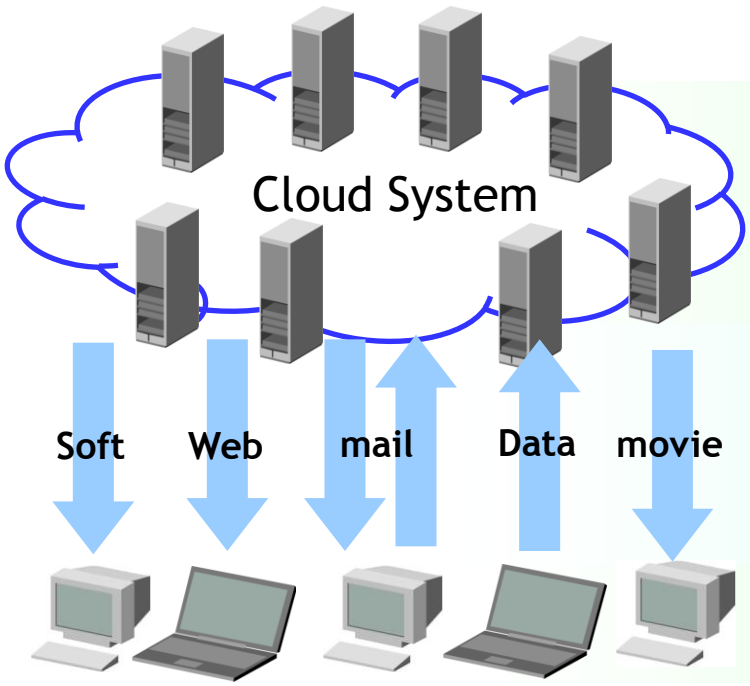
3.5-E16 newspapers

Global Forest x1.5

IT system for Info-plosion



Advantages of Flash Memory in Info-plosion World



Tech. Items which allow cloud computing

Server & Storage	**High IOPS performance that can handle huge requests from large number of users.**
Network	**Ultra broadband infrastructure High performance router and switch, etc.**
Thin Client	**Small, light, low power and reliable**

Global Side : High Performance Low Power

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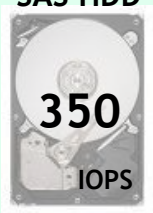


Enterprise SSD achieves x100 of IO performance than ent.HDD

Local Side : Small & Light Low Power

≒ COST

Instead of capacity, form factor, weight, and ECO will be important.

Estimation of Energy Cost Reduction

With the information explosion,
IT systems will consume about 2.8 trillion kWh of electricity in 2020.

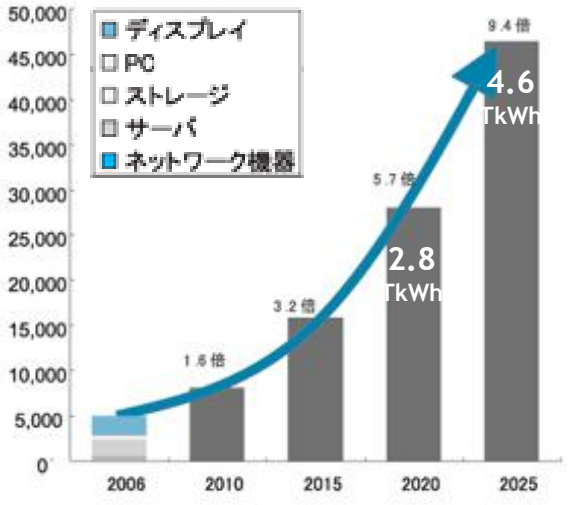
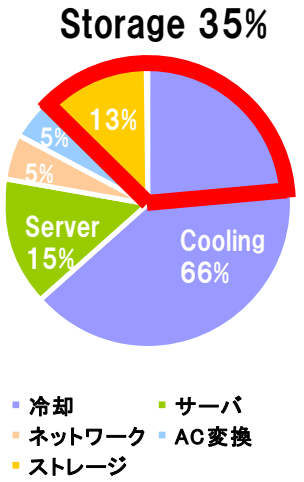
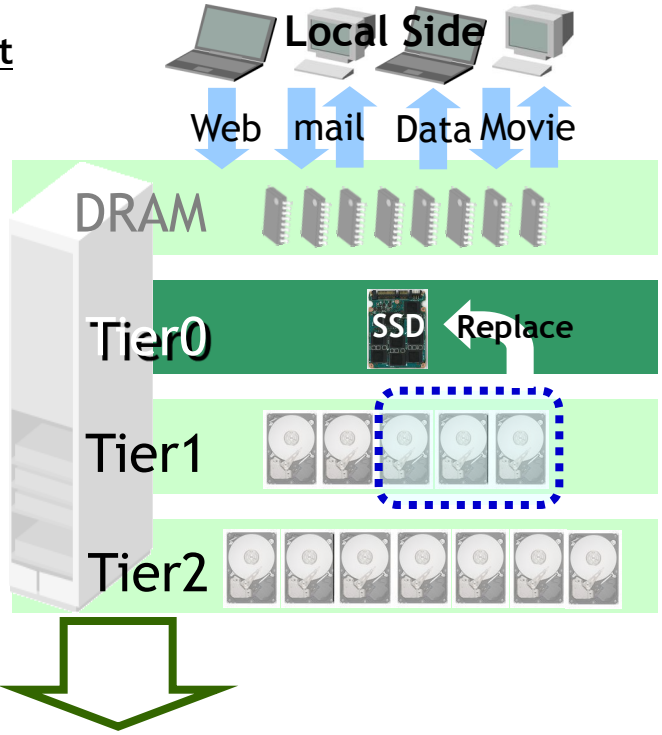


図2　IT関連の消費電力の将来推計

出展：経済産業省

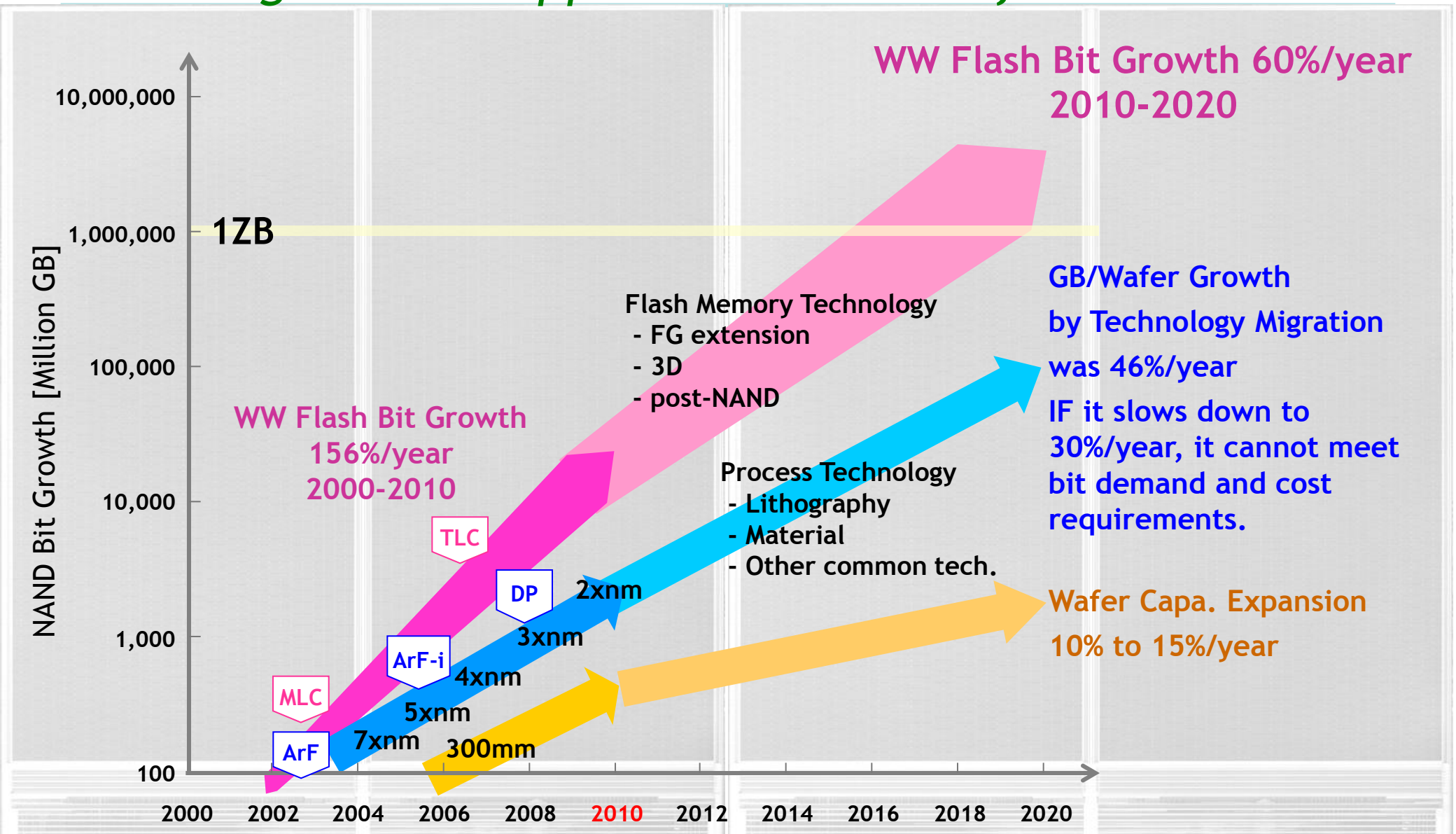
Data Center Energy Cost





Flash can reduce the power consumption of IT systems by the up to 25%.
It will reduce world wide power consumption by as much as 2.5%.
This 0.7 trillion kWh saving is equivalent to 70 nuclear power plants.

Technologies that Support the Growth of Flash



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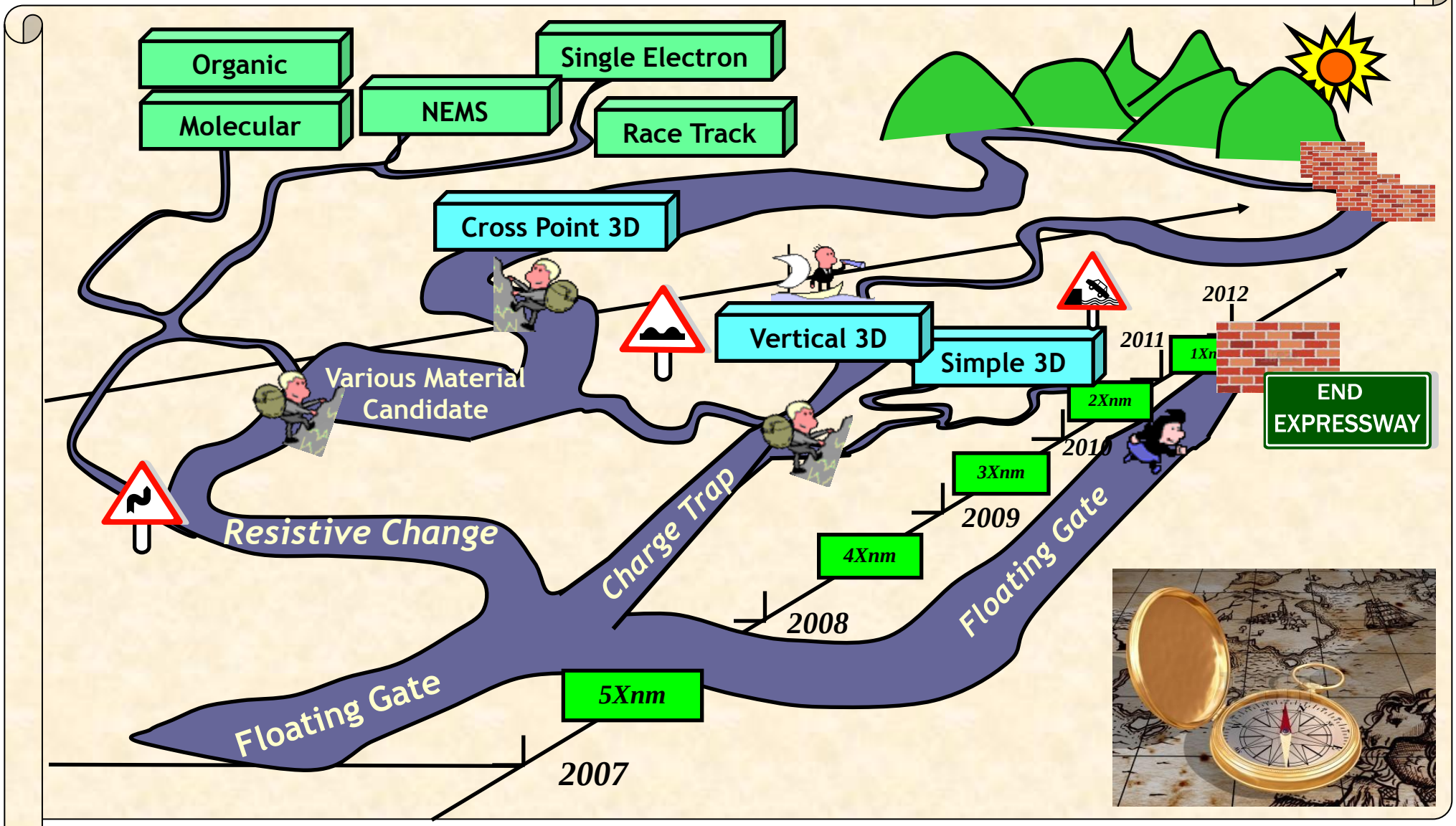
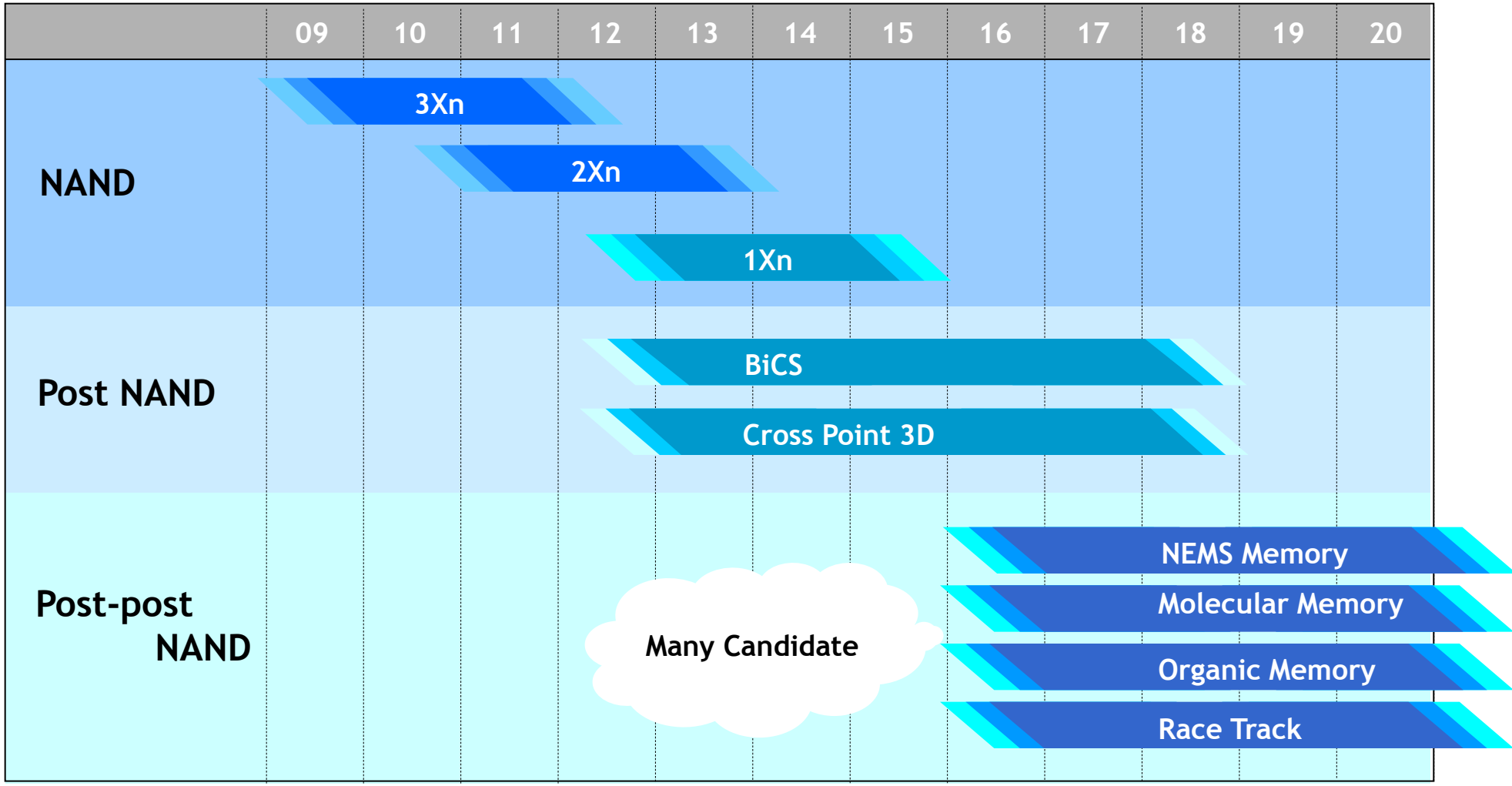
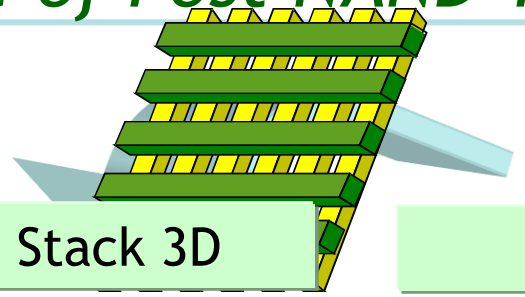
The Winding Road Map to the Future



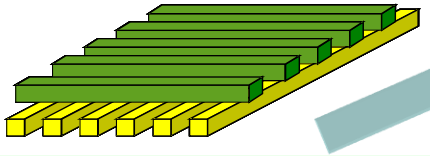
Flash Memory Road Map



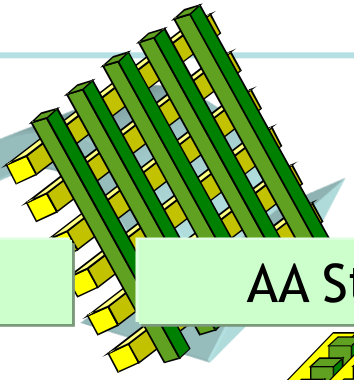
Essence of Post NAND Technology



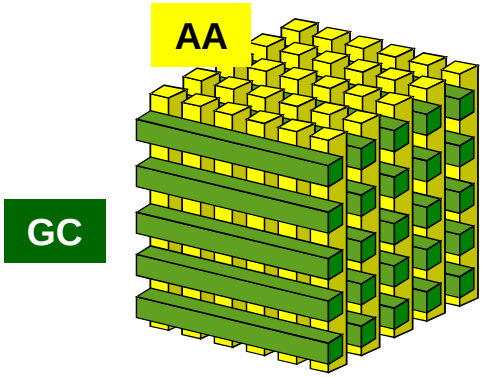
GC Stack 3D



Simple Stack 3D

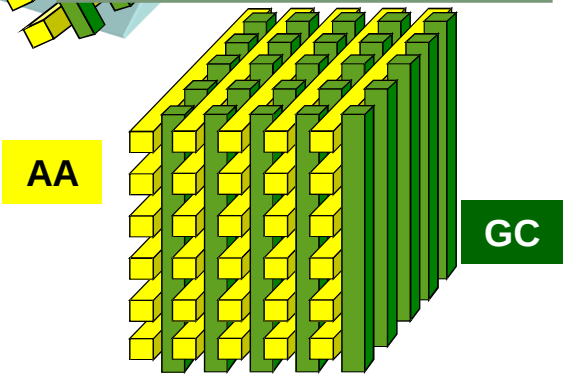


AA Stack 3D

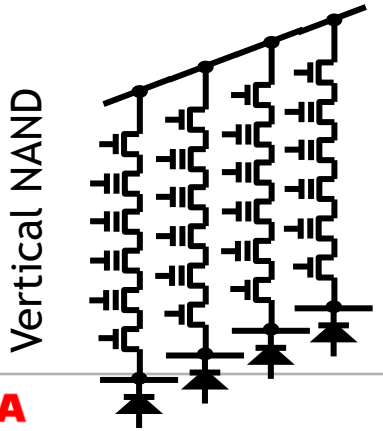


BiCS

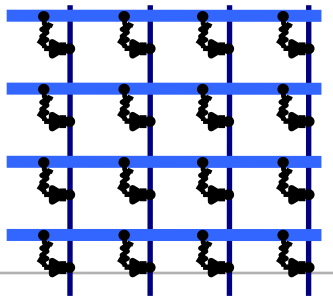
Complex & less cost effective



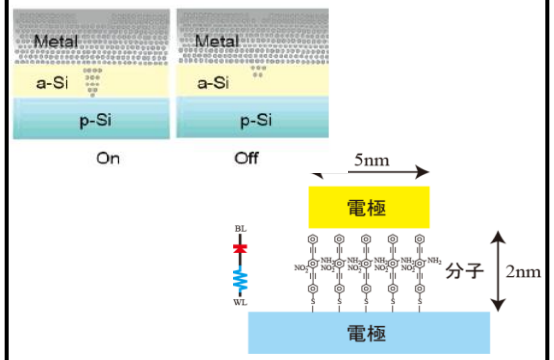
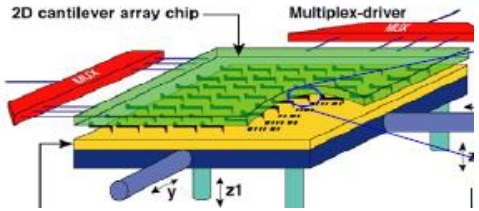
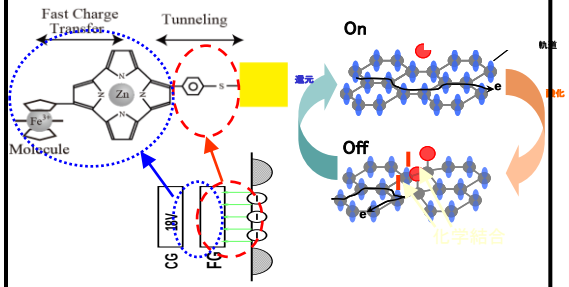
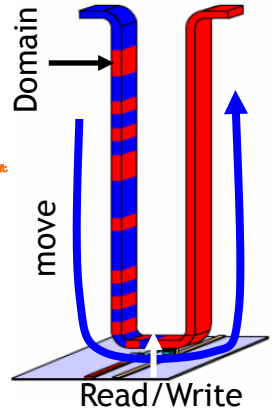
Scaling Limitation



Cross Point 3D

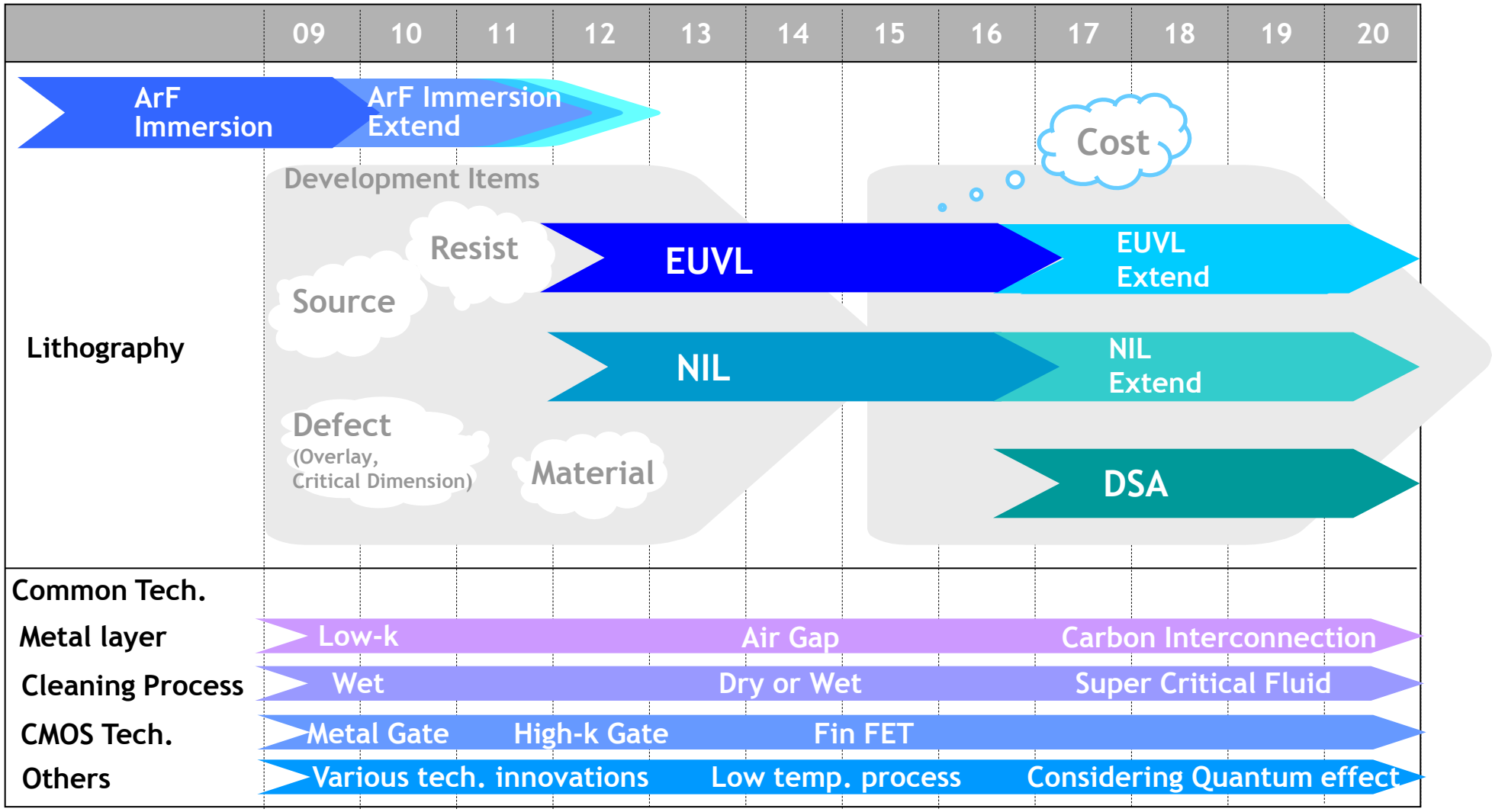


Post-post NAND Candidates

Category	Cross Point Type	Multi probe Mechanical Type	Charge Trap Type	Others
Structure	Inorganic Organic	NEMS	Molecular Switch Graphene	Race Track
	ION Memory 	 HDD like Architecture		
Merit	Simple Structure Extended tech. of current tech	No Fine Wiring High Bit Density	Different path for Read and Write	No Fine Wiring No Multi Layer
Issues	Wiring and Cost Operating Power	Probing Accuracy	Stability of Chemical Bond Molecular Structure	High Power Large Cell
Source	W. Lu *et al.*, *Nano Lett.* 8, 392 (2008). J. Chen et. Al., Science 286, 1550(1999)	IBM Journal of Research and Development, Volume 52, 493(2008).	http://www.zettacore.com/overview.html arXiv:0712.2026v1, IEEE EDL29p952(2008).	Parkin: Science 320, 190(2008).

Technology Challenges

NIL: Nanoimprint Lithography
DSA: Direct Self Assembly



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In 2020, 35 zetabytes of data will be generated.

Future ECO IT system will have to adopt Flash memory due to high speed and low power consumption.

Slow down of Flash technology migration will cause big losses, because alternatives have cost disadvantages.

The extension of NAND flash with technology migration and acceleration of post-NAND development are needed.

How can the semiconductor industry overcome this global scale challenge?

Toshiba's commitment:

- *respond to the information explosion*
- *continue to be the leader in the Flash memory industry*
- *collaborate with partners who develop advanced EUV process technologies*

It is not the strongest

of the species that survives,

nor the most intelligent that survives.

It is the one

that is the most adaptable to change.

Charles Darwin

I look forward to constructive, successful discussions during this symposium.

Thank you for your attention


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